CHAPTER 9. SHIPMENTS ANALYSIS

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CHAPTER 9. SHIPMENTS ANALYSIS

9.1 INTRODUCTION

The Shipment Model for walk-in coolers and freezers (walk-ins or WICF) provides several necessary inputs to the national energy savings (NES), net present value (NPV) calculations, and the manufacturer impacts analysis (MIA). Key outputs of the model are the number of shipments in every year, the total stock of installed units in every year, and the energy efficiency of the installed stock. This chapter describes the U.S. Department of Energy's (DOE's) methodology for projecting annual shipments and presents results.

The Shipments Model results are driven primarily by historical stock data for walk-ins and assumptions about the rates at which that stock will grow and turn over. The flow chart presented in Figure 9.1.1 outlines the structure of the Shipments Model.

The model assumes that, in each year, any given piece of existing WICF equipment stock either ages by 1 year or fails. For the purpose of characterizing replacement rates for the Shipments Model, DOE refers to equipment failures. However, DOE recognizes that failure rates as used here represent a simplified model of real-world failure conditions. For refrigeration systems, it is not uncommon for only part of a unit to fail and be replaced. The failure rates in this model represent the average replacement rate for refrigeration system equipment. Similarly, failure in WICF envelopes can be less clear-cut than for many types of commercial equipment. More information on envelope failures is provided in the Market and Technology Assessment (preliminary technical support document [TSD] chapter 3).

Failed equipment is replaced with equipment of the same type. When any new equipment ships (either to replace failed equipment or as part of market growth), it is required to meet whatever efficiency standards are in place. In this way, energy efficient equipment is modeled as percolating into the stock over time. Provisions are made in the model for either partial or complete replacement, depending on the nature of the malfunction in the equipment. In addition, new equipment can be shipped into new commercial floor space, and old equipment can be removed through demolitions (not shown in Figure 9.1.1).

The Shipments Model is in a Microsoft Excel spreadsheet format that is accessible on the Internet at: http://www1.eere.energy.gov/buildings/appliance_standards/commercial/wicf.html. Appendix 10C of this TSD will provide instructions for using the spreadsheet.

The rest of this chapter explains the Shipments Model in more detail. Section 9.2 presents the mathematical formulation of the model, Section 9.3 describes the data input to the model, and section 9.4 presents the results for the base-case energy conservation standard level scenario and discusses the development of higher standard scenarios. The energy conservation standards for walk-ins will set the maximum-rated energy consumption for all equipment within an equipment class. DOE refers to each standard level considered as a "candidate standard level" (CSL). Walk-ins are an atypical product in that they consist of two separate pieces of equipment: the thermal envelope and the refrigeration system, which cools the space inside the envelope. DOE will set separate standards for envelopes and refrigeration systems. DOE forecasts shipments for each equipment class of both envelopes and refrigeration systems. The shipments are related (because each walk-in requires one envelope and one refrigeration system to operate), but are not identical (because envelopes and refrigeration systems are replaced at different rates).

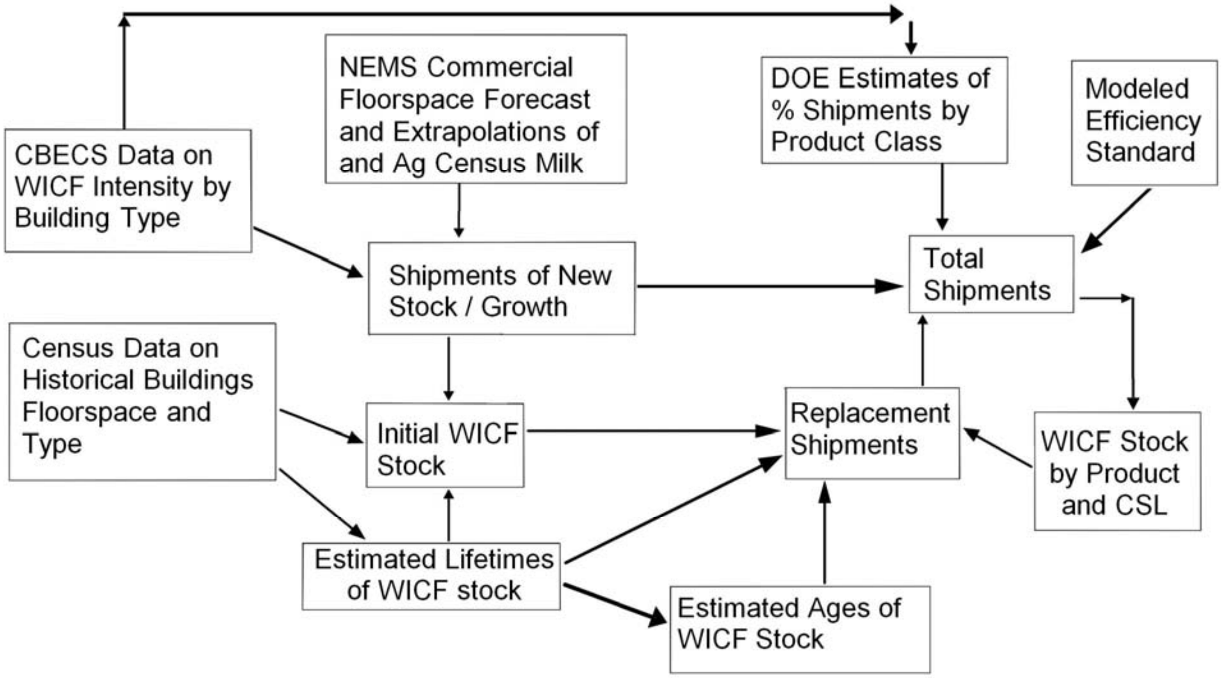

Figure 9.1.1 Flow Chart Showing Inputs to the Shipments Model

In section 9.2, DOE describes the mathematical formulation of the Shipments Model. In section 9.3, DOE lists the different data sources and assumptions used in this analysis. Section 9.4 provides results.

9.2 SHIPMENTS MODEL EQUATIONS

The Shipments Model describes WICF equipment stock flows as a function of time and equipment age. The equations presented in this chapter describe each combination of envelope type and refrigeration type independently. Results are then aggregated by envelope type and by refrigeration system type to determine the shipments of each type of equipment.

DOE formulates the equations as updates of the distribution of stock in year t as a function of stock age. The equations distinguish between the age of the envelope, a_{env}, and the age of the refrigeration system, a_{ref}. For each year of the analysis period, the stock is tracked for all possible combinations of unit ages, a_{env} and a_{ref}. This is because the refrigeration systems require more frequent replacement than envelopes on average, so it is not uncommon for a walk-in envelope to be of a different age (typically older) than the associated refrigeration system. Note that this also means that shipments of refrigeration systems are modeled to always exceed shipments of envelopes, even though they are used in a one-to-one ratio in the stock.

DOE's approach first combines national statistics on the existing stock of walk-ins with expected growth rates to estimate the total stock of walk-ins going forward. DOE estimates these growth rates as a function of the extent of relevant commercial floor space. DOE assumes that whenever an envelope or refrigeration system fails, it is replaced with equipment from the same equipment class. Therefore, DOE can combine these stock forecasts with estimated lifetimes of both envelopes and refrigeration systems to produce shipment forecasts. Sales of new and replacement equipment are recorded by the year of the equipment (distinguishing between envelope age and refrigeration system age), and each annual vintage is depreciated over the estimated life of the equipment to determine the rate of replacement shipments necessary to sustain the stock at the forecasted level.

9.2.1 Mathematical Formulation of the Shipments Model

The Shipments Model estimates the number of shipments of each type of WICF equipment in a given year by tracking stock age and type. At the end of each year, every piece of equipment either ages by 1 year or is replaced. Whenever new equipment replaces failed equipment, the new equipment is by definition zero years old. Similarly, whenever new stock is added through market growth, this new equipment is also zero years old. Therefore, in a given year, shipments of WICF equipment are equal in quantity to the number of units at age zero.

The numerous possible combinations of WICF equipment add considerable complexity to the otherwise straightforward calculations used within the Shipments Model. While not all types of envelopes and refrigeration systems can be combined, there are 36 (meaningful) combinations of envelope and refrigeration system equipment classes. See the energy use characterization (preliminary TSD chapter 7, section 2.1) for additional details. For each of these equipment class combinations, the model tracks each possible combination of envelope CSL and refrigeration system CSL. For each of these possible combinations of equipment class and CSL, the model also tracks the number of shipments and size of the stock in each year. And for each of these possible combinations, the model tracks the age distribution of units in each year. Thus, the total stock of walk-ins in the year t is the sum of all possible combinations of the following:

$$STOCK_t = \sum_{EC_{env}, EC_{ref}, CSL_{env}, CSL_{ref}, a_{env}, a_{ref}} (STOCK_{EC_{env}, EC_{ref}, CSL_{env}, CSL_{ref}, a_{env}, a_{ref}, t}) \qquad \textbf{Eq. 9.1}$$

where

t	=	year,
EC_{env}	=	equipment class of the envelope,
EC_{ref}	=	equipment class of the refrigeration system,
CSL_{env}	=	CSL of the envelope,
CSL_{ref}	=	CSL of the refrigeration system,
a_{env}	=	age of the envelope, and
a_{ref}	=	age of the refrigeration system.

9.2.1.1 Size of the Stock

DOE assumes that the major driver of WICF stock is commercial floor space of the major establishments that use walk-ins: food service establishments, food sales establishments (comprising both grocery stores and convenience stores), and "other" (encompassing a wide variety of minor walk-in applications, *e.g.*, florists and stadiums). In addition, the WICF stock accounts for dairy farms for which DOE estimated growth in number of walk-ins using output (estimated by pounds of milk production per year) rather than floor space. For simplicity, the following text refers to all these categories as "building types."

DOE did not have sufficient information to forecast the change over time in intensity of walk-ins per square foot of commercial floor space (or per pound of milk production). Therefore, in the model, the stock of walk-ins is assumed to be a constant factor of commercial floorspace (and pounds of milk production). As both of these quantities are expected to grow over time, DOE forecasts that the installed stock of walk-ins nationwide will also grow over time. However, limited data available from the U.S. Economic Census suggest that the walk-in market may have been essentially flat from the period 1997 to 2007, rather than steadily growing. DOE intends to re-examine the issue of WICF stock growth rates in the next stage of this analysis and seeks further comment on growth trends in the walk-in industry.

For each of the five building types (food service, grocery stores, convenience stores, dairy farms, and other), the Shipments Model estimates stock growth in the following manner:

$$STOCK_{B,t} = STOCK_{B,0} \times SF_t \times I_B \qquad \textbf{Eq. 9.2}$$

where

$STOCK_{B,t}$	=	the stock of walk-ins in building type B in the year t,
$STOCK_{B,0}$	=	the stock of walk-ins in building type B in year zero (the first year before the analysis period, or 2014,
SF_t	=	square footage (or pounds milk production) of building type *B* in year *t*,
I_B	=	walk-in intensity, *i.e.*, the number of walk-ins per square foot (or pounds of milk production) for building type *B*.

This equation is repeated across all equipment classes and CSLs. Summing across these and across all building types gives the total number of walk-ins in the market.

9.2.1.2 Replacement Events

As noted above, the Shipments Model estimates shipments based on the size and age of the stock in each year. In any given year, t, the model estimates shipments as the sum of growth (*i.e.*, any increase in total stock relative to the previous year) plus any units that are shipped to replace failed units. The number of failed units is therefore a key element of the Shipments Model.

The number of replacement units in any given year equals the number of units that break or are discarded. In any given year, each individual walk-in experiences one of three possible replacement events:

- The envelope fails. In this case, DOE assumes that the refrigeration system is replaced as well.
- The refrigeration system fails while the envelope does not. In this case, DOE assumes that the refrigeration system is replaced, but the envelope simply ages by 1 year.

- Neither piece of equipment fails or is removed. In this case, both pieces simply age by one year.

All replacements are assumed to comply with any efficiency standards, whereas existing units are not assumed to comply. Because DOE is regulating envelopes and refrigeration systems separately, this assumption applies even to the case where only the refrigeration system is replaced. In that case, the refrigeration system is assumed to be replaced with a standards-compliant refrigeration system, yet the pre-existing envelope would not necessarily comply with the standard. Further detail on the efficiency mix of the stock is provided in the National Impact Analysis (preliminary TSD chapter 10).

Some percentage of each category of walk-ins STOCK (t, EC_{env}, EC_{ref}, CSL_{env}, CSL_{ref}, a_{env}, a_{ref}) will experience one of these life events in a given year. The percentage of each category that experiences these life events is equal to the probability that a single unit of that type would experience a given life event. Those probabilities are as follows.

- Probability of envelope failure:

$$F_{env}(a_{env}) = W_{env}(a_{env}) \qquad \textbf{Eq. 9.3}$$

where

F_{env} = probability that the envelope fails, whether or not the refrigeration system fails, and

W_{env} = probability of envelope failure at envelope age a_{env} based on the Weibull lifetime distributions given in Table 9.3.4.

- Probability of refrigeration system failure when the envelope does not fail:

$$F_{refonly} = W_{ref}(a_{env}, a_{ref}) \times (1 - W_{env}(a_{env})) \qquad \textbf{Eq. 9.4}$$

where

$F_{refonly}$ = the probability that the refrigeration system fails, but the envelope does not fail, and

F_{env} = the probability of refrigeration system failure at refrigeration system age a_{ref} based on the Weibull lifetime distributions given in Table 9.3.4.

- Probability that neither piece of equipment fails:

$$F_{none} = 1 – W_{env}(a_{env}) – W_{ref}(a_{env}, a_{ref}) \times (1 - W_{env}(a_{env})) \qquad \textbf{Eq. 9.5}$$

where

$F_{refonly}$ = the probability that neither system fails.

In the model, all broken equipment is assumed to be replaced in kind, and every store renovation that removes a walk-in is assumed to be offset by another store renovation that adds a walk-in. The following sections present the equations used to represent each possible event.

9.3 DATA INPUTS

This section outlines the inputs that DOE used in constructing its Shipments Model.

9.3.1 Historical Stock

As noted in the Market and Technology Assessment (preliminary TSD chapter 3), some high-level data are available on the historical value of walk-ins shipped by year. However, in terms of the number of units, DOE was unable to acquire detailed shipment information. In part, this is because manufacturers of envelopes typically track shipments in square feet of panel rather than number of units. Since more detailed data are available on the historical stock, DOE bases its shipment estimates primarily on the historical stock. In the preliminary analysis, DOE uses two different approaches to estimate stock trends over time from this information. For the Market and Technology Assessment, which focuses on historical shipments, DOE extrapolates these numbers linearly. This assessment indicates a very low rate of growth in the WICF market. However, in the preliminary analysis Shipments Model, which focuses on future shipments, DOE assumes that the long-run growth rate in the WICF market will recover somewhat and uses the following approach instead. DOE seeks further comment on what long-run growth rates to assume in the WICF market for the final analysis.

DOE relied on three main sources of historical stock data for walk-ins: the 2003 Commercial Buildings Energy Consumption Survey (CBECS)[1], the 2007 U.S. Economic Census[2], and manufacturer interviews. The CBECS and Census data provided detailed information on the number of commercial walk-ins in total nationwide and by category of building.

A small number of walk-ins operate in dairy farms, which are not covered under CBECS because they are considered industrial sector applications. For these walk-ins, DOE used the 2007 U.S. Agricultural Census.[3]

In mathematical terms, this means that in equation 9.2, IB was based on data from CBECS, whereas SF_t was based on data from the U.S. Census. Ideally, DOE would be able to base all variables in the same equation from one data source, but this is not done because of the different strengths of the two different data sets. While CBECS provides more detailed information about the nature of the walk-in stock by building type, the Census is based on a larger sample size.

Within each of the equipment categories, the shipments data must be disaggregated into detailed equipment and temperature ranges for the shipment analysis. Since neither of these sources distinguished between categories of walk-ins, DOE next used manufacturer input to apportion the share of shipments by product class.

9.3.2 Commercial Floor Space and Market Saturation

As discussed in section 9.2.1.2, the amount of commercial floor space (and pounds of milk production is the main driver for WICF stock and is appropriately one of the basic inputs into the Shipments Model. For this analysis, commercial square footage with walk-ins refers to both new and existing stock of building types.

DOE took the projected floor space construction from the National Energy Modeling System (NEMS) projection published in April 2009 update to the *Annual Energy Outlook 2009* (AEO 2009-B)[4]. AEO 2009-B gives the projections for years 2010, 2015, 2020, 2025, and 2030. For years beyond this, DOE derived commercial floor-space data by linear extrapolation of the existing years. Beyond 2030, DOE extrapolated floor-space estimates from NEMS-projected data between 2020 and 2030.

As noted above, for the dairy farm building type, DOE used pounds of milk production estimates rather than floor space estimates. These estimates were taken from the 2007 U.S. Agricultural Census.[5]

Table 9.3.1 shows the growth rates applied to each building type. Because NEMS does not distinguish between different types of food sales building stock, DOE forecast both grocery stores and convenience stores as growing at the rate of the food sales category in NEMS.

Table 9.3.1 Forecasted Cumulative Growth by Building Type Since 2007

	Food Sales	Food Service	Dairy Farms	Other
Year	Square Feet	Square Feet	Pounds of Milk Produced	Square Feet
2015	9%	9%	16%	17%
2020	16%	17%	26%	27%
2025	25%	26%	38%	38%
2030	35%	35%	50%	48%
2035 (extrapolated)	44%	45%	64%	62%
2040 (extrapolated)	54%	56%	79%	77%
2045 (extrapolated)	65%	67%	96%	93%

Following is an example of how to read Table 9.3.1: the stock of walk-ins in food services in 2035 is modeled as equal to 145 percent of the initial (2014) stock: 100 percent of the initial stock persists as existing shipments, plus 45 percent in the form of growth.

9.3.3 Distribution of Walk-ins by Equipment Class

Table 9.3.2 shows DOE's assumptions as to the share of equipment classes. These assumptions are based on manufacturer interviews and DOE estimates. As noted above, many possible combinations of envelope and refrigeration system equipment classes would be meaningless or clearly inferior to some other combination (*e.g.*, any small cooler and large low-temperature refrigeration system). Blank entries in the table refer to such equipment class combinations. For further information on the size definitions, please see the energy use characterization (preliminary TSD chapter 7).

Table 9.3.2 Percent of Shipped Walk-ins by Product Class

Class/ Size Code	Small Non-Display Cooler	Medium Non-Display Cooler	Large Non-Display Cooler	Small Display Cooler	Medium Display Cooler	Large Display Cooler	Small Non-Display Freezer	Medium Non-Display Freezer	Large Non-Display Freezer	Small Display Freezer	Medium Display Freezer	Large Display Freezer
Small Medium-Temperature Indoor Dedicated System	1%											
Large Medium-Temperature Indoor Dedicated System		2%	0%	0%	0%	0%						
Small Medium-Temperature Outdoor Dedicated System	7%											
Large Medium-Temperature Outdoor Dedicated System		11%	9%	0%	2%	1%						
Small Medium-Temperature Multiplex System	0%											
Large Medium-Temperature Multiplex System		20%	6%	0%	1%	4%						
Small Low Temperature Indoor Dedicated System							1%					
Large Low Temperature Indoor Dedicated System								1%	0%	0%	0%	0%
Small Low Temperature Outdoor Dedicated System							5%					
Large Low Temperature Outdoor Dedicated System								5%	5%	0%	3%	1%
Small Low Temperature Multiplex System							0%					
Large Low Temperature Multiplex System								13%	2%	0%	0%	0%

Sources: *Manufacturer Interviews*

9.3.3.1 Equipment Lifetime and Age

The lifetime of both types of walk-in equipment (envelopes and refrigeration systems) is an important input to the Shipments Model. As the lifetimes of WICF equipment become shorter, the shipments of such equipment will need to be more frequent to sustain a given level of stock. DOE was unable to obtain detailed data on the distribution of lifetimes by equipment type. Public comments from interested parties on the framework document and DOE manufacturer interviews did, however, provide several different estimates of walk-in equipment lifetimes. These estimates are listed in Table 9.3.3.

Table 9.3.3 Estimates of Walk-in Lifetimes by Equipment Type

Estimate Source	Estimated Envelope Lifetime (years)	Estimated Refrigeration System Lifetime (years)
AHRI, No. 33 at p. 7*	12-15	8-12
Manitowoc Foodservice Group, Public Meeting Transcript, No. 15 at p. 204*	25 is “not unreasonable”	10 is “not unreasonable”
Craig Industries, Public Meeting Transcript, No. 15 at p. 205*		Less than 10
Manufacturer Interviews	12-15 is typical, 8-20 not unheard of	7-8

*Public comment on the framework document

DOE observed significant variation in the available estimates of equipment lifetime and concluded that the lifetime of actual walk-in equipment is highly variable. In part, this may be because equipment is not always retired due to mechanical failure, but may instead be retired for financial reasons (*e.g.*, a restaurant might close down and no longer need its walk-in) or other non-mechanical reasons. DOE intends to revisit the issue of equipment lifetimes in the next phase of its analysis and seeks further comment on the issue of average equipment lifetimes and the distribution of those lifetimes around the average.

Rather than assuming a single lifetime for all units, DOE created distributions of potential lifetimes for both envelopes and refrigeration systems based on the above estimates. The distributions were assumed to take the form of a Weibull curve, a common shape for equipment failure rates. True Weibull distributions go out to infinity at ever smaller shares, *i.e.*, there might be a vanishingly small chance of a unit lasting for many hundreds of years. So for analytical tractability, it was necessary to truncate the maximum possible lifetime of walk-ins modeled at some cut-off point. DOE therefore assumed that no envelope would last beyond 25 years, and no refrigeration system would last beyond 15 years. The resultant lifetime distributions are shown in Table 9.3.4:

Table 9.3.4 Cumulative Failure Rates by Equipment Type

Equipment Age (years)	Assumed Envelope Cumulative Failure Rate (percent)	Assumed Refrigeration System Cumulative Failure Rate (percent)
0	0.0	0.0
1	0.0	0.0
2	0.0	0.4
3	0.0	2.5
4	0.0	8.3
5	0.2	19.0
6	0.8	34.8
7	1.8	53.8
8	3.7	72.
9	6.5	86.3
10	10.6	94.8
11	15.9	98.5
12	22.6	99.7
13	30.6	>99.9
14	39.5	>99.9
15	49.0	>99.9
16	58.6	100.0
17	67.8	100.0
18	76.1	100.0
19	83.1	100.0
20	88.8	100.0
21	93.0	100.0
22	95.9	100.0
23	97.8	100.0
24	98.9	100.0
25	99.5	100.0
26	100.0	100.0
27+	100.0	100.0

As shown in Table 9.3.4, refrigeration systems typically exhibit a shorter lifetime than envelopes. It is therefore common that a refrigeration system will fail when the associated envelope still has useful life remaining. As noted above, DOE assumed that when this happens, the refrigeration system is replaced with a standards-compliant system, but the envelope remains. However, DOE assumed that when an envelope fails, it is replaced along with a new refrigeration system. For these reasons, shipments of refrigeration systems are greater than shipments of envelopes, even though the two types of equipment are used in a 1:1 ratio.

9.3.3.2 Age Distributions of Existing Stock

The age distribution of the existing walk-in stock is an important input that affects forecasted replacement rates for walk-ins in the analysis period. Assumptions were made about the ages of existing stock because DOE was unable to find any information on the distribution of ages of the existing stock. Because the failure rates in a Weibull distribution are not constant every year, it seems unlikely that the Nation’s stock of walk-ins would be evenly distributed across all possible ages. Instead, over time, the stock would likely gravitate towards whatever age distribution is stable at the failure rates and growth rates for these particular products. To determine what that age distribution might look like, DOE modeled a hypothetical WICF market in which initially all units were of random age and modeled 100 years passing in this hypothetical market. This market had a growth rate of zero and failure rates equal to the rates in Table 9.3.4. After 100 years, this hypothetical market settled into an equilibrium age distribution, shown in

Table 9.3.5. DOE then used this age distribution as an estimate of the likely age distribution of the actual WICF stock in the United States today. DOE also tracked each possible combination of envelope age and refrigeration system age (e.g., the percentage of walk-ins with a 6-year-old envelope and a 3-year-old refrigeration system), but those results are not presented here. As with all other information used in the model, those results are available online at http://www.eere.energy.gov/buildings/appliance_standards/ commercial_products/wicf.html.

Table 9.3.5 Assumed Age Distribution of Initial Stock

Equipment Age (years)	Share of Envelopes of this Age (percent)	Share of Refrigeration System of this Age (percent)
0	6.5%	15.2%
1	6.4%	14.3%
2	6.3%	13.5%
3	6.3%	12.7%
4	6.2%	11.6%
5	6.2%	10.2%
6	6.1%	8.4%
7	6.1%	6.3%
8	6.0%	4.1%
9	5.9%	2.3%
10	5.7%	1.0%
11	5.4%	0.3%
12	5.0%	0.1%
13	4.5%	< 0.1%
14	4.0%	< 0.1%
15	3.4%	0.0%
16	2.8%	0.0%
17	2.2%	0.0%
18	1.7%	0.0%
19	1.2%	0.0%
20	0.8%	0.0%
21	0.5%	0.0%
22	0.3%	0.0%
23	0.2%	0.0%
24	0.1%	0.0%
25	0.1%	0.0%
26	<0.1%	0.0%
27+	0.0%	0.0%

9.3.3.3 Price Elasticity

Economic theory suggests that changes in the price of WICF equipment resulting from this standard might affect the number of shipments, a phenomenon known as “price elasticity.” This might take the form of either a decrease in shipments, in cases where purchase costs increase; or an increase in shipments, in cases where life-cycle costs decrease.

However, in practice, DOE has no information with which to calibrate such a relationship in the WICF market. Further, manufacturer interviews indicated that manufacturers do not believe that the nature of this relationship is particularly significant in either direction in the walk-in market. Therefore, for the preliminary analysis, DOE presumes that the shipments do not change between the base case and standards case.

9.4 RESULTS

Table 9.4.1 shows DOE’s shipments forecast for WICF envelopes by envelope equipment class. Table 9.4.2 shows the refrigeration system forecast. As noted above, DOE forecasts that refrigeration system shipments will exceed envelope shipments because the shorter equipment lifetime of refrigeration systems means they need more frequent replacements.

Table 9.4.1 Forecasted Shipments of New and Replacement WICF Envelopes, 2015-2045

WICF Envelope Systems	Year and Number of Units Shipped						
	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**
Non-Display Cooler Small	11,933	12,839	13,572	14,486	15,574	16,702	17,835
Non-Display Cooler Medium	49,895	53,686	56,750	60,570	65,119	69,838	74,576
Non-Display Cooler Large	22,398	24,100	25,475	27,190	29,232	31,350	33,477
Display Cooler Small	-	-	-	-	-	-	-
Display Cooler Medium	3,880	4,184	4,431	4,747	5,105	5,486	5,871
Display Cooler Large	7,385	7,965	8,436	9,037	9,718	10,444	11,176
Non-Display Freezer Small	8,337	8,999	9,527	10,161	10,855	11,645	12,416
Non-Display Freezer Medium	27,705	29,905	31,661	33,766	36,073	38,697	41,261
Non-Display Freezer Large	11,217	12,108	12,818	13,671	14,605	15,667	16,705
Display Freezer Small	-	-	-	-	-	-	-
Display Freezer Medium	4,739	5,098	5,405	5,870	6,443	6,963	7,533
Display Freezer Large	1,185	1,275	1,351	1,468	1,611	1,741	1,883
Total	**148,673**	**160,160**	**169,428**	**180,966**	**194,336**	**208,533**	**222,735**

Table 9.4.2 Forecasted Shipments of New and Replacement WICF Refrigeration Systems, 2015-2045

WICF Refrigeration Systems	**Year and Number of Units Shipped**						
	2015	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**
Dedicated Medium Temperature Indoor Small	4,884	5,185	5,539	5,938	6,367	6,809	7,289
Dedicated Medium Temperature Indoor Large	9,437	10,020	10,707	11,483	12,314	13,173	14,106
Dedicated Medium Temperature Outdoor Small	22,251	23,620	25,232	27,051	29,004	31,018	33,205
Dedicated Medium Temperature Outdoor Large	76,903	81,649	87,249	93,569	100,337	107,332	114,927
Multiplex system Medium Temperature Small	-	-	-	-	-	-	-
Multiplex system Medium Temperature Large	103,619	110,018	117,572	126,098	135,224	144,659	154,905
Dedicated Low Temperature Indoor Small	3,427	3,640	3,884	4,164	4,453	4,756	5,082
Dedicated Low Temperature Indoor Large	3,416	3,629	3,872	4,151	4,440	4,741	5,067
Dedicated Low Temperature Outdoor Small	15,610	16,583	17,695	18,970	20,288	21,665	23,152
Dedicated Low Temperature Outdoor Large	46,668	49,620	53,183	57,199	61,456	65,899	70,745
Multiplex system Low Temperature Small	-	-	-	-	-	-	-
Multiplex system Low Temperature Large	51,966	55,207	58,907	63,150	67,538	72,124	77,075
Total	**338,182**	**359,170**	**383,841**	**411,774**	**441,419**	**472,176**	**505,552**

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